IJSPT

ORIGINAL RESEARCH

NORMATIVE VALUES FOR THE FUNCTIONAL MOVEMENT SCREENTM IN ADOLESCENT SCHOOL AGED CHILDREN

Allan Abraham, MPT[1]
Rajasekar Sannasi MPT[1]
Rohit Nair MPT[1]

ABSTRACT

Background: International sports programs have established pre-participation athletic screening procedures as an essential component to identify athletes that are at a high risk of becoming injured. The Functional Movement Screen (FMS™) is a screening instrument intended to evaluate deficiencies in the mobility and stability of an athlete that might be linked to injury. To date, there are no published normative values for the FMS™ in adolescent school aged children. The purpose of this study was to establish normative values for the FMS™ in adolescent school aged children (10 to 17 years). Secondary aims were to investigate whether the performance differed between boys and girls and between those with or without previous history of injury.

Methods: 1005 adolescent school students, including both males and females between the ages of 10 and 17 years who fulfilled the inclusion and exclusion criteria, were selected for the study. The test administration procedures, instructions and scoring process associated with the standardized version of the test were followed in order to ensure accuracy in scoring. The components of the FMS™ include the deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raise, trunk stability push up, and rotary stability.

Results: The mean composite FMS™ score was 14.59 (CI 14.43 - 14.74) out of a possible total of 21. There was a statistically significant difference in scores between females and males ($p = .000$). But no statistically significant difference in scores existed between those who reported a previous injury and those who did not report previous injury ($p = .300$). The variables like age ($r = -.038$, $p = .225$), height($r = .065$, $p = .040$), weight ($r = .103$, $p = .001$) did not show a strong correlations with the mean composite score.

Conclusion: This study provides normative values for the FMS™ in adolescent school aged children, which could assist in evaluation of functional mobility and stability in this population.

Level of evidence: 2c

Keywords: Adolescent aged school children, Functional Movement Screen™, normative values.

[1] Srinivas College of Physiotherapy and Research Centre, Mangalore-575001, Karnataka, India

Statement of Institutional Review Board:- The study has been approved by Srinivas college of physiotherapy and research center ethical committee

CORRESPONDING AUTHOR

Allan Abraham
Srinivas College of Physiotherapy and Research Centre
Mangalore-575001
Karnataka
India
E-mail: allyred57@gmail.com

INTRODUCTION

The past decade has seen an explosion in the number of children participating in team and solo sports. At a young age, sport is for enjoyment, health and personal development. This balance changes as a competitive element intervenes. Subsequently, young athletes train harder and longer and participate in sports throughout the year. As an undesired but inevitable consequence, sports-related injuries have increased significantly.[1,2] A report of the 1995 to 1997 high school sport seasons indicates that more than two million injuries were sustained, requiring 500,000 doctor visits and 30,000 hospitalizations in United States (US).[3] The volume of injuries reported in this setting, along with the fact that many of the more significant sports-related injuries may lead to long-term physical impairment, warrants research into the possibility of utilizing pre-participation screening methods that are able to identify young athletes that are at a high risk of becoming injured.[3]

In an attempt to create a pre-participation functional evaluation, Gray Cook and Lee Burton developed the Functional Movement Screen (FMS) ™. This screening tool is comprised of a battery of tests to simultaneously evaluate joint mobility and stability through a series of seven movements. Although none of the tests specific are to any individual sport, these FMS™ tests challenge both upper and lower extremities and trunk in functional tasks, unlike some types of athletic performance testing, which fails to test these aspects. As designed, the evaluation is practical, as the desired movements can be tested within five to ten minutes, allowing the clinician to quickly screen for deficiencies that may require more in-depth evaluation and possible rehabilitation in order to reduce the risk of injury.The tests of the FMS™ include the deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raise, trunk stability push up, and rotary stability accompanied by three clearing tests. Each test is scored on a three-point scale, with three indicating perfect performance, two; minor deficits or perfect performance with modifications, and one, the inability to perform the movement. A score of 0 indicates that pain was reported during the movement. Three attempts were allowed for each test (deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raise, trunk stability push-up and rotary stability) with the highest score recorded. For the tests that are conducted on the right and the left, the lower of the two net scores was used for the final score. Three of the tests (shoulder mobility, trunk stability push-up and rotary stability) also have associated clearing tests (spinal flexion, spinal extension, shoulder internal rotation with flexion). They are scored as either positive or negative with a positive response indicating that pain was reproduced during the examination movement. The maximum score is 21.[4,5]

Asymmetry and weak links in one's basic functional movement can be identified by Functional movement screen. Asymmetries heightened the risk of injuries 2.3 times during a professional season which was found during FMS assessment.[11] Influence of limb dominance on asymmetry has been addressed by various studies. Vanden Abeele might be amongst the first to suggest a relationship between laterality and functional gait symmetry.[6] A theory proposed by Previc indicated that asymmetry in the lower limb should correlate positively with the measure that reflects unilateral dominance.[7] Sadegi et al stated that functional asymmetry might be related to limb dominance.[8]

The FMS™ has been used with sports teams as a pre season screen to detect injury risk and to develop specific intervention programs in order to prevent injuries. It is also has been utilized to evaluate and reduce injury risk in specific occupational groups (e.g. fire-fighters)[9,10,11,12] The FMS™ has been used to determine injury risks in various groups including military personnel and female collegiate athletes.[13,14] Onate et al conducted a study on real-time intersession and inter-rater reliability of the FMS ™ when used with healthy active adults. They found that all the tasks displayed moderate to high intersession reliability and good to high inter rater reliability.[15]Another study was conducted to establish normative values for the FMS™ in a population of active, healthy individuals.[16] Secondary aims were to investigate whether performance differed between males and females, between those with and without a previous history of injury, and to establish real-time inter-rater reliability of the FMS™. Schneiders et al established normative values for FMS™ for young active individuals. They also found that there was no statistically significant difference in scores between females and males, or those who reported a previous injury and those who did not. Inter-rater reliability for the composite FMS score demonstrated excellent reliability.[16]

To date, there are no published normative values for score on the FMS™ on the adolescent population. The use of FMS™ in the adolescent school-aged population can be enhanced by the availability of reference values, as well permitting evaluation of functional mobility and stability in this group. Young athletes' scores can be compared to the normative reference values. The purpose of this study was to establish normative values for the FMS™ in adolescent school aged children (10 to 17 years). Secondary aims were to investigate whether the performance differed between boys and girls and between those with or without previous history of injury.

METHODS

Subjects

This study utilized a prospective cross sectional design. A total of 1005 subjects were selected for the study by convenience sampling. The sample consisted of male and female adolescent school aged children between the ages of 10 to 17 years. The subjects were selected from various schools across cities like Mumbai, Aurangabad, and Mangalore, India. The data was collected by a primary investigator, an experienced sports physical therapist, who underwent in house training for the scoring and administration of FMS™, by studying training video and relevant literature. The purpose of the study was explained to all the subjects and informed consent was obtained from the guardians. Subjects were included in the study if they participated regularly in physical activity at a competitive or recreational level (According ACSM guidelines for Physical Activity 2008) and if they were between the ages of 10 and 17 years. Exclusion criteria were use of mobility aid or a prophylactic device, history of recent (less than 6 weeks) musculoskeletal or head injury (using Cantu grading system 2001) which could have affected their performance at FMS™. The study had been approved by Srinivas College of Physiotherapy and Research Centre Ethical Committee and written informed consent was obtained from all the parents or guardians of the subjects prior to data collection

Data collection procedures

Each subject completed a short form regarding their injury history and demographic information along with information about the primary sports they played and primary position in them. Each participant's weight was measured in kilograms and height in centimeters. Descriptive information about the subjects including limb dominance, was collected to describe any asymmetry that may have been found during testing. Four short tests, which have been shown to provide a valid measure of footedness, were conducted.[17] Handedness was determined by observing the hand with which the subject filled the questionnaire. Despite observing the hand used by the subjects to fill the form, the primary investigator also checked for ambidextrous individuals by inquiring the participants, notably, the investigator failed to come across any. Each participant was instructed in the performance of all test movements by the primary investigator to ensure a standardized explanation. The scoring was recorded done on a FMS™ scoring sheet.

Statistical Methods

Comprehensive description of the participants and FMS™ data were provided by computing frequencies, means, standard deviation, 95% confidence intervals (CI) for males and females separately and for all participants combined. Frequencies and percentages of the total scores were also computed and number of participants who scored at or below the cut-off value of 14 was tabulated. Using the FMS™ to assess the injury risk in athletes requires a defined failure, or cut-off score. The most widely accepted failure or cut-off score referenced in the literature, when using the 21-point FMS™, is a composite FMS™ score of 14. This referenced value comes from a study by Kiesel et al conducted in 2007, using a cohort of professional football players.[11] The cut-off score of 14 is supported by an O'Connor et al study of a large number of marine officer candidates, a study by Chorba et al with female collegiate athletes, and in a Lisman et al study also using marine officers.[13,14,21] Independent t-tests were used to examine for potential between those who had reported and had not sustained an injury in the previous six months, with the exact probability values presented. Score distributions of individual FMS™ scores were also tabulated. Chi-square tests were used to evaluate if there were any significant differences between males and females in the distribution of scores for the different FMS™ tests. Correlation of FMS™ scores with various variables including age, weight and height were computed using Karl Pearson correlation**.** All calculations were performed using SPSS (version 22.0) and the prior level of significance was set at $p \leq 0.05$.

Results

The subjects for this study (N = 1005) included 548 males and 457 females between the ages of 10 to 17 years. Handedness distributions of the subjects studied were 87.9% right handed and rest were left handed. Footedness distribution of the subjects studied 86.9% right footed and the rest were left footed. Fifteen point one percent of the subjects had reported of having sustained an injury in the previous six months, from which they had recovered.

The subjects completed the entire FMS™. The descriptive data for the FMS™ and its composite items are presented in Table 1. Individual FMS™ tests showing difference between males and females are presented in Table 2. There was significant difference in composite scores between male and female subjects ($t = 4.89$, $p = .000$). In this study 46.5% (465/1005) of the participants had a score of 14 or less which might indicate a potentially higher risk of injury according to results of the study performed by Kiesel et al on professional football players.[11]

The score distributions for individual FMS™ tests are presented in Table 3. Seventeen point three percent recorded a score of 3 in the rotary stability test out of the total population which was high compared to the previous study that reported normative values for the FMS™ on young active adults between the ages of 18 to 40 years, in which 88.0% (184/209) of all the participants were scored as a `2´, 11.0% (23/209) a `1´and only 1.0% (2/209) `3´. [16] The score for this test in the current study was high, as compared to the previous study but the scores cannot be statistically compared, as sample size and the age of the target population in the both studies are different.

There was no statistically significant difference in scores between those who reported a previous injury during last six months and those who did not ($t = 1.04$, $p = .300$)

It is important to note that there exists a very weak correlation of the mean composite score with age ($r = -.038$, $p = .225$). With respect to other variables like height($r = .065$, $p = .040$) and weight ($r = .103$, $p = .001$), only weak correlations exist with the mean composite score.

DISCUSSION

The focus of this study was to describe normative values in adolescents for FMS™, which consists of a battery of tests developed in 1997 that relies upon common, basic movements to identify athletes that may be at an elevated risk of injury. The FMS™ was constructed around seven basic movement patterns that were deemed to represent foundational actions of many sport maneuvers. No evidence has yet been published to establish the normative values for functional movement screen in high school children. The availability of a normative reference data could increase the clinical utility of FMS™ in younger populations, to screen for movements that could provide risk for injury in children and adolescents.

The mean composite score reported in this study is 14.59 which is slightly lower than that reported for a group of average athletes between the ages of 18

Table 1. *Descriptive data for the FMS™ and its composite items*

	Mean	95% Confidence Interval for Mean		SD	t value
		Lower Bound	Upper Bound		
Combined scores	14.59	14.43	14.74	2.48	4.89‡
Males	14.93*	14.71	15.15	2.61	
Females	14.17†	13.97	14.38	2.24	

*†‡ difference in the mean composite scores for males and females ($t = 4.89$, $p = .000$)

Table 2. *ndividual FMS™ tests showing difference between Males and Females*

FMS TESTS	GENDER	Mean	95% Confidence Interval for Mean		t value	p value
			Lower Bound	Upper Bound		
Deep squat	Male	2.38	2.33	2.42	.09	.931
	Female	2.38	2.33	2.43		
	Total	2.38	2.35	2.41		
Hurdle step	Male	2.03	1.98	2.07	.92	.359
	Female	2.06	2.01	2.11		
	Total	2.04	2.01	2.08		
Inline lunge	Male	2.10	2.05	2.16	4.38	.000*
	Female	1.92	1.85	1.98		
	Total	2.02	1.98	2.06		
Shoulder mobility	Male	2.57	2.53	2.62	.44	.659
	Female	2.59	2.54	2.64		
	Total	2.58	2.54	2.61		
Active SLR	Male	2.00	1.95	2.05	1.14	.256
	Female	1.96	1.91	2.00		
	Total	1.98	1.95	2.01		
Trunk stability	Male	1.91	1.85	1.97	8.29	.000†
	Female	1.58	1.53	1.63		
	Total	1.76	1.72	1.80		
Rotatry stability	Male	2.01	1.95	2.06	4.70	.000‡
	Female	1.82	1.76	1.87		
	Total	1.92	1.88	1.96		
Total	Male	14.93	14.71	15.15	4.89	.000§
	Female	14.17	13.97	14.38		
	Combine	14.59	14.43	14.74		

Table 3. *The score distributions for individual FMS™ scores*

FMS TESTS	1.00		2.00		3.00	
	Freq	%	Freq	%	Freq	%
Deep Squat	32	3.2%	560	55.7%	413	41.1%
Hurdle Step	147	14.6%	670	66.7%	188	18.7%
Inline Lunge	219	21.8%	549	54.6%	237	23.6%
Shoulder Mobility	27	2.7%	370	36.8%	608	60.5%
Active SLR	163	16.2%	699	69.6%	143	14.2%
Trunk Stability Push Up	362	36.0%	512	50.9%	131	13.0%
Rotary Stability	254	25.3%	577	57.4%	174	17.3%

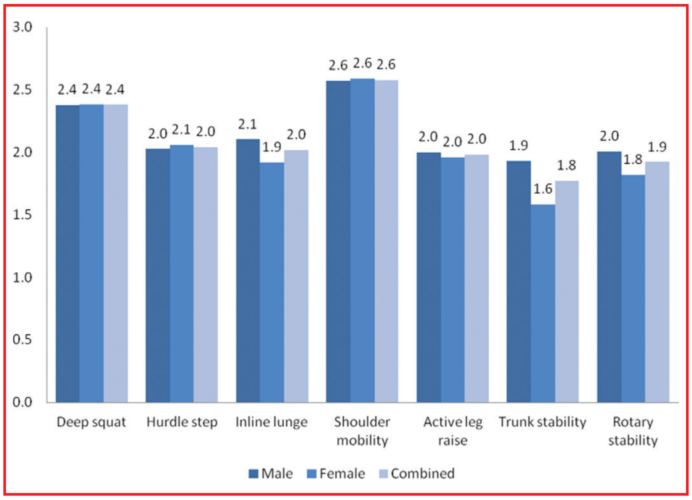

Figure 1. *Distribution of mean scores on different FMS™ tests.*

Figure Legend: There is significant difference in scores between Male and Female (t = 4.89, p = .000). The difference was found in individual FMS tests like Inline lunge (t value = 4.38, p value= .000), Shoulder mobility (t value =2.49, p value =.013) , Active SLR(t value =6.44, p value = .000), Trunk stability push up (t value = 8.29, p value =.000), Rotary stability(t value =4.70 , p value = .000)

to 40 years (mean score 15.7),[16] professional male football players (mean score 16.9)[11] and male Gaelic field sports players (mean score 15.56).[18] The normative value reported in middle aged adults is 14.14, [19] which was similar to the mean composite score reported for the children and adolescents in this study. It might be expected that professional football players and average athletes between age group of 18 and 40 years would score better due to their physical maturity, conditioning, fitness, age, and body composition, compared to the status of general adolescent aged school subjects.

It is important to note that there was no strong correlation of FMS™ composite scores with any of the variables studied. A very weak negative correlation exists between the mean composite score and age (r= -.038, p=.225). With respect to other variables like height (r= .065, p= .040) and weight (r=.103, p=.001), only weak correlations exist with the mean composite score. Since the variables like age, height , weight do not show a strong correlation with the mean composite score, it can be proposed that the mean composite score can be used as the normative value for the adolescent aged school children and adolescents between the ages of 10 and 17 years.

According to the study done on normative values reported in middle aged adults, age was significantly related to FMS™ scores.[19] Duncan and colleagues that reported both BMI and physical activity were predictors of FMS™ scores in elementary aged children;[20] however, BMI was the more dominant of the factors. Hence further research is warranted, wherein FMS™ scores can be compared to various age groups and other variables like BMI and physical activity level, especially in adolescent aged school populations.

There was a significant difference in scores between male and female subjects (t = 4.89, p = .000). But the difference in the mean composite scores was less than a point. Hence it can be proposed that the mean composite score can be used as the normative value for FMS™ for both male and female adolescent aged school children between the ages of 10 to 17 years. Significant differences were apparent between females and males on four individual FMS™ tests. Males were on average better on the in line lunge, active straight leg raise, trunk stability push-up and the rotary stability tests than females. The inline lunge test assesses the stance leg stability as well as the step leg mobility of the performer. The active straight leg raise associated with flexibility in the hamstring muscles, while the trunk stability push-up is associated with upper body strength and stability (including core stability in the sagittal plane), and the rotary stability test with transverse plane (rotational) core stability [4,5]

The validity of FMS™ as a screening tool to predict injury has been established through the use of an evidence based cut off score. Three studies have utilized screening statistics to establish the cut off score of <= 14 as being appropriate to identify individuals who have greater odds for sustaining an injury.[11,21,22] In the current study 46.5%(465/1005) of the participants had a score of 14 or less which might indicate potentially higher risk for injury. This is in comparison to the 22% of the professional football players in the Kiesel et al study[11] and 89% in the subsequent study by Kiesel et al.[12] The study by Peate et al conducted on firefighters suggested that a cut off score of <= 16 was strongly associated with an injury.[23] The finding of a significant difference in FMS™ scores in those with a prior injury was not observed in active adults.[16] The difference between these studies is likely associated with the difference in the common magnitude of injuries in fire-fighters or professional athletes as opposed to a general population. Moreover, the absence of any study, to establish cut off scores in the adolescent aged school population, has limited the clinical utility of FMS™ to understand what individual characteristics may be related to FMS™ composite scores in this population.

There are several strengths of this study. This study is the first of its kind to provide comprehensive descriptive profile of the participants and large sample size on a primarily adolescent aged school population. This will allow for both meaningful comparisons between females and males and the potential to make useful future comparisons with similar studies. The provision of a normative dataset with narrow confidence intervals could enhance the use of FMS™ to detect biomechanical deficits in fundamental movement that may limit human performance. The clinical utility of FMS™ is currently limited by its lack of normative reference values the said population. This study aimed to fill this void by providing normative reference values for the adolescent aged school population. Future research should target at specific sporting population in adolescent aged school children and should look for improvement in FMS™ scores following intervention in these sporting groups. Future studies should try to validate the use of FMS™ in adolescent aged school population by establishing a cut-off score to predict injury rate and performance in the said population.

CONCLUSION

With the advent of increased injuries in adolescent aged school population, it is essential to introduce a pre screening procedure prior to any sporting event that would be helpful to determine any potential risks for injury. The FMS™ is a robust, practical, easy to administer screening tool which can be used in athletic as well as general population. The normative value provided for the FMS™ in this study may be helpful to identify abnormal overall scores in adolescent aged school population

REFERENCES

1. Maffulli N. The growing child in sport. *Br Med Bull*. 1992;48:561–568.
2. Rowley S. The effect of intensive training in young athletes: A Review of the Research Literature. Section 4: 'The effects of intensive training on the psychological and psychosocial development of the young athlete. *Sports Council*; 1986.
3. Powell, JW, Barber-Foss, MS. (1999). Injury patterns in selected high school sports: A review of the 1995 - 1997 seasons. *JAT*. 1999;34(3):277-284.
4. Cook G, Burton L, Hoogenboom B. Pre-participation screening: The use of fundamental movements as an assessment of function - Part 1. *N Am J Sports Phys Ther*. 2006;1(2):62-72.
5. Cook G, Burton L, Hoogenboom B. Pre-participation screening: The use of fundamental movements as an assessment of function - Part 2. *N Am J Sports Phys Ther*. 2006; 1(3): 132-139.
6. Vanden-Abeele J. Comments on the functional asymmetry of the lower extremities. *Cortex* 1980;16(2):325–9.
7. Previc FH. A general theory concerning the prenatal origins of cerebral lateralization in humans. *Psychol Rev* 1991;98:299–334.
8. Sadeghi H, Allard P, Duhaime M. Functional gait asymmetry in able-bodied subjects. *Hum Mov Sci* 1997;16:243–58.
9. Cowen VS. Functional fitness improvements after a worksite-based yoga initiative *Bodyw Mov Ther*. 2010;14:50-54
10. Peate W, Bates G, Lunda K, Francis S, Bellamy K. Core strength: A new model for injury prediction and prevention. *J Occup Med Toxicol*. 2007;2(1):art3.
11. Kiesel K, Plisky PJ, Voight ML. Can serious injury in professional football be predicted by a preseason functional movement screen? *N Am J Sports Phys Ther*. 2007;2(3):147-158.
12. Kiesel K, Plisky PJ, Butler R. Functional movement test scores improve following a standardized offseason intervention program in professional football players. *Scand J Med Sci Sports*. 2009;21:287-292.
13. Chorba R, Chorba D, Bouillion L, Overmyer C, Landis J. Use of a functional movement screening tool to determine injury risk in female collegiate athletes *N Am J Sports Phys Ther*. 2010;5(2): 47-52.
14. Lisman P, O'Connor FG, Deuster PA, Knapik JJ. Functional Movement Screen and Aerobic Fitness Predict Injuries in Military Training. *Med Sci Sports Exerc*. 2012 Nov 27. [Epub ahead ofprint].
15. Onate, James A; Dewey, Thomas; Kollock, Roger O; Thomas, Kathleen S; Van Lunen, Bonnie L; DeMaio, Marlene; Ringleb, Stacie I. Real-Time Intersession and Interrater Reliability of the Functional

Movement Screen .*Journal of Strength & Conditioning Research:* February 2012;26(2):408-415.

16. G. Schneiders, A. Davidsson, E. Horman, and J. S. Sullivan, Functional Movement Screen Normative values in a young active population, *International Journal of Sports Physical Therapy*, 2011;6:75–82.
17. Schneiders AG, Sullivan SJ, O'Malley KJ, Clarke SV, Knappstein SA, Taylor LJ. A valid and reliable clinical determination of footedness. *PM R*. 2010;2(9): 835-841.
18. Domhnaill Fox , Edwenia O'Malley, Catherine Blake Normative data for the Functional Movement Screen in male Gaelic field sports, *Physical Therapy in Sport* xxx (2013) 1-6.
19. Perry, FT and Koehle, MS. Normative data for the functional movement screen in middle-aged adults. *J Strength Cond.* 2013; Res 27(2): 458–462.
20. Duncan MJ, Stanley M. Functional Movement Is Negatively Associated with Weight Status and Positively Associated with Physical Activity in British Primary School Children. *Journal of Obesity*; E-Published March 26 2012.
21. O'Connor FG, Deuster PA, Davis J, Pappas CG, Knapik JJ. Functional movement screening: predicting injuries in officer candidates. *Med Sci Sports Exerc.* 2011 Dec;43(12):2224-30.
22. Robert J.Butler, Phillip J. Plisky, Kyle B. Kiesel. Reliability of functional movement screen using the 100-point scoring scale. *Athletic Training & Sports Health Care* 2012; 4(3):103-109.
23. Peate WF, Bates G, Lunda K, Francis S, Bellamy K. Core strength: a new model for injury prediction and prevention. *J Occup Med Toxicol.* 2007;11:2:3.